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The formation of ice on electrical conductors during heavy falls of wet snow

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Summary

An example is described of severe disruption to electricity supplies caused by the freezing of wet snow on conductors, and an explanation is offered of the freezing mechanism. The same mechanism is used to account for the freezing of wet snow on locomotive pantographs on electrified main lines.

Introduction

The snowstorm of 16/17 March 1979, which affected mainly the northern half of England and Wales, severely disrupted electricity supplies over north-west Wales. According to MANWEB (Merseyside and North Wales Electricity Board) engineers, Anglesey was by far the worst affected area with damage to high-voltage overhead equipment at approximately 70 locations. The damage on Anglesey, which occurred on the night of 16/17th, mainly consisted of the breaking of overhead conductors by ice loading but there were examples of broken poles or pole-top steelwork. MANWEB engineers reported that conductors were covered with a core of ice about 5 cm in diameter. Over mainland areas of north-west Wales faults were also caused by snow-laden trees making contact with overhead conductors.

MANWEB contacted the Meteorological Office at RAF Valley to see if we could offer an explanation of why damage was so bad on Anglesey where apparently snow accumulations were much less than on the mainland (by 09 GMT on 17 March 4 cm of snow had been measured at Valley compared with depths of over 40 cm at many places on the mainland).

Synoptic situation

On 16/17 March a depression remained slow-moving near south-east England with a strong north to north-east airstream over much of the British Isles. Figure 1 shows the synoptic chart for 00 GMT on 17 March when the storm was at its height. The tephigram for Aughton at the same time (see Figure 2) should be representative of the air mass affecting Anglesey. Below 720 mb the air was very cold but was overridden at higher levels by much warmer air associated with the warm frontal zone which was moving slowly north over eastern England. The temperature of the surface air on the Lancashire coast was near to or a little below freezing (see Figure 3) but calculations indicate that the temperature of the cold air crossing the Irish Sea (sea temperature near 6 °C) should have risen to about 3·5 °C on reaching the north coast of Anglesey. At Valley temperatures remained between 1·0 and 0·5 °C because

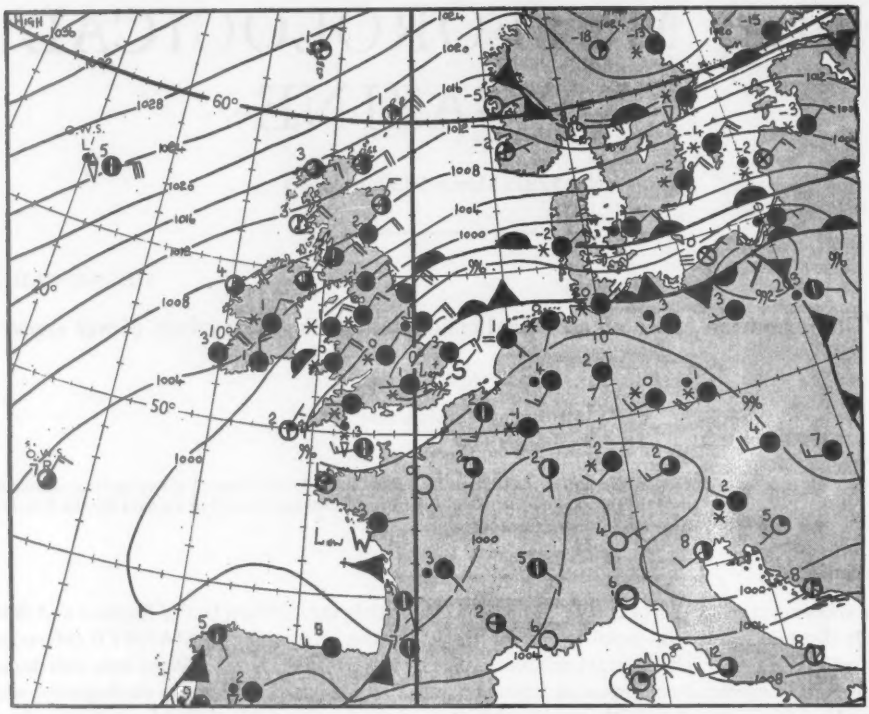

Figure 1. Surface synoptic chart for 00 GMT, 17 March 1979.

of the cooling effect of the falling snow and the distance away from the windward coast (about 25 km). The snowfall resulted mainly from warm air overriding cold, but was accentuated by convection over the Irish Sea.

Observations at Valley

Snow showers commenced at Valley around 01 GMT on the 16th with the showers becoming more frequent until continuous precipitation was reported by 11 GMT. Snow of light or moderate intensity continued until 12 GMT on the 17th with further periods of light snow until 05 GMT on the 18th. Between 06 GMT on the 16th and 06 GMT on the 18th, an equivalent rainfall of 35 mm was recorded. Snow did not settle until dusk on the 16th and by 09 GMT on the 17th an accumulation of 4 cm was recorded, with equivalent rainfall from 18 GMT on the 16th to 09 GMT on the 17th of 21·7 mm. The water equivalent of this snow was 12·7 mm, a high value but perhaps typical of very wet wind-packed snow. On the night of 16/17th the dry-bulb temperature varied between 1·0 and 0·5 °C and the wet-bulb temperature between 0·7 and 0·4 °C. As would be expected in conditions of thawing snow, both grass and concrete thermometers registered minimum temperatures of 0·0 °C. The mean overnight wind was 030°, 10 m s^{-1} with gusts 17·5 m s^{-1}.

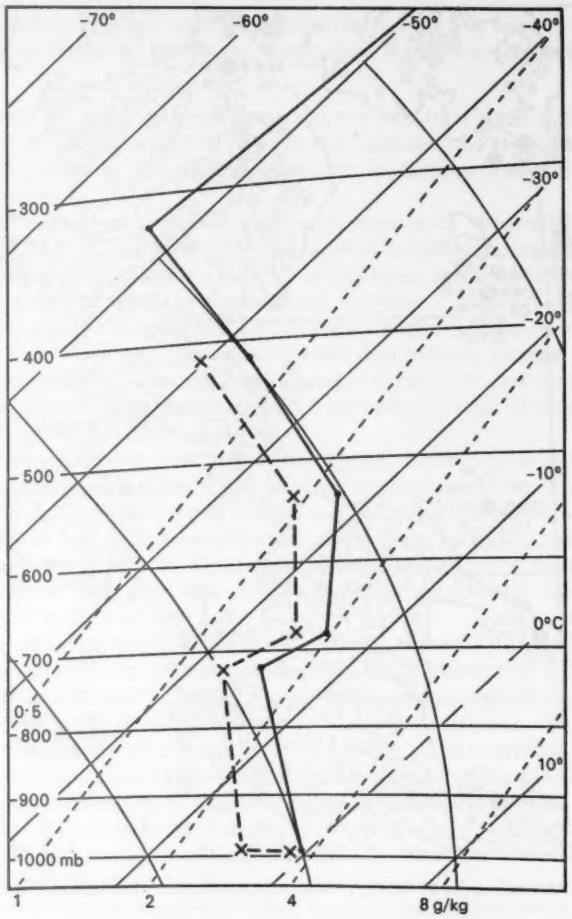

Figure 2. Tephigram for Aughton (near Liverpool) at 00 GMT on 17 March 1979.
•——• dry-bulb temperature; × – – – × dew-point temperature.

The author, driving to the office on the morning of the 17th, observed that road surfaces were covered with wet snow with no sign of ice formation; however, on fences, poles and cables exposed to the strong wind there were considerable accumulations of ice-like, frozen wet snow. Numerous telegraph poles were down with others leaning perilously.

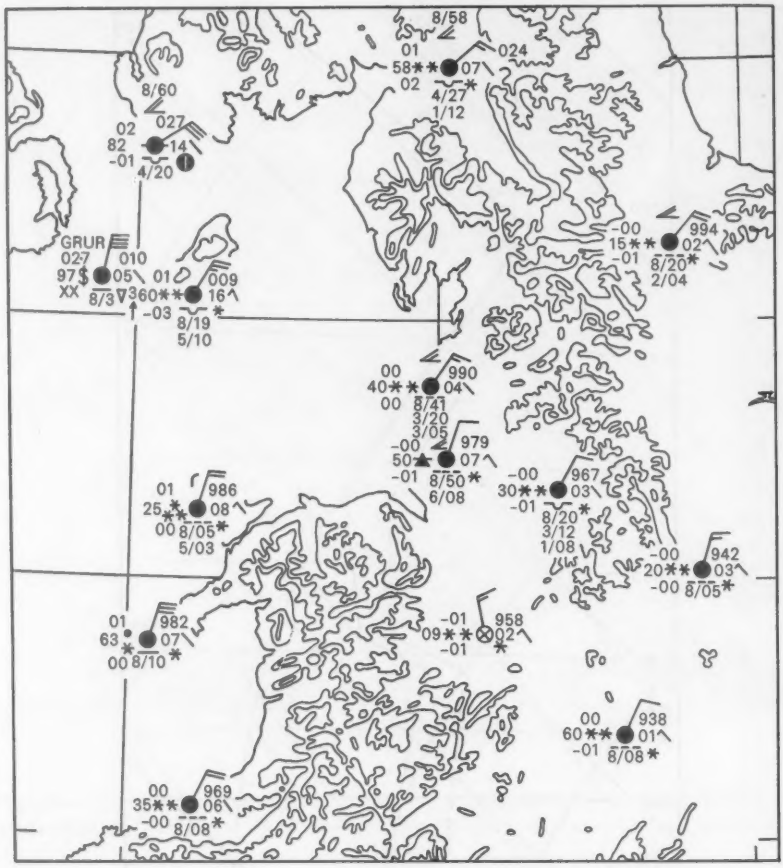

Figure 3. Plot of observations for 00 GMT, 17 March 1979. Contours are indicated at 200 m and 400 m.

Discussion

The damage to overhead conductors obviously resulted from the accumulations of frozen wet snow and was made worse by oscillations in the conductors caused by sudden shedding of the ice load as a result of strong winds. Unlike rime icing, which commonly occurs in upland areas when a cloud sheet with its temperature remaining below zero results in water droplets freezing on impact to form heavy deposits of ice (Sarson 1956, Phillips 1956), damage caused by freezing wet snow is quite rare. However, Foot (1972) describes cases very similar to the events on Anglesey during 16/17 March 1979. He gives the necessary conditions likely to lead to severe icing on conductors as:

(1) a dry-bulb temperature above 0 °C,
(2) continuous moderate or heavy snow—suggested rate $\geqslant 1$ cm h^{-1}, and
(3) a strong surface wind—the higher the temperature the stronger the wind required to cause freezing.

Foot considered that the wet-bulb temperature was not important since, if the snowflakes were melting as they fell, they would continue to do so on the conductor and therefore evaporative cooling was not an important parameter. However, no satisfactory explanation is given of how the freezing on the conductor takes place.

The following mechanism is put forward to explain the occurrence. A snowflake falling into a layer with a temperature above 0 °C may begin to melt even when the wet-bulb temperature is a little below 0 °C. This is because, since the snowflake is blown by and hence to a considerable extent moves with the horizontal wind flow, and since the psychrometric constant is related to the rate of ventilation, cooling by evaporation will be relatively slow. When the snowflake impinges on a surface exposed to a strong wind, the wind flow relative to the snowflake will then suddenly increase by a large factor and strong cooling by evaporation will increase the likelihood of freezing. For refreezing to occur the value of the wet-bulb temperature for a particular wind speed will be very critical. If the wet-bulb temperature is too low the snowflake will not melt before impact.

At Valley during the period when freezing was taking place, the steep lapse rate of moisture content indicated on the Aughton tephigram would give wet-bulb temperatures below 0 °C at elevations only a little above screen level, although at screen level it remained above 0 °C. Over much of the mainland of north-west Wales wet- and dry-bulb temperatures were likely to have been at or below 0 °C with no icing problems. This was because of the generally elevated nature of the land compared with Anglesey, and also because the steep hills close to the north coast would prevent much incursion inland of air warmed over the Irish Sea.

Wet snow freezing on conductors can also cause problems with railway operations. Parrey (1970) describes a case when southbound train services between the Midlands and London were disrupted because the weight of ice and snow brought down the locomotive pantographs and prevented contact with the overhead lines. Little or no pantograph trouble was experienced with northbound trains. His explanation for the freezing of wet snow was that the trains had travelled from an area where temperatures were below 0 °C into an area with temperatures above freezing and that the wet snow then froze on the pantographs which were sub-zero. However, Ludlam (1951) shows that the thermal capacity of a conductor is not a significant heat source or sink (a typical conductor of radius 0·5 cm and at a temperature of −5 °C can only freeze a layer of ice 2×10^{-3} cm thick, assuming that the conductor only gains heat from freezing water at 0 °C).

It is suggested that cooling by evaporation when wet-bulb temperatures were just below 0 °C was again the cause. In the case of a moving train there is no need for a strong surface wind since the train will be in an apparent wind. This suggests that on a day with no wind, ice might form on the moving pantographs but not on overhead lines. With a strong surface wind the situation would be more complicated. For example a train moving against a strong wind would be more liable to icing than a train moving with the wind.

Conclusion

Wet snowfalls occur in most winters and yet the formation of ice on conductors is uncommon. For freezing of wet snow to occur certain conditions must prevail and as indicated the wet-bulb temperature

is the most critical of the parameters. It is suggested that when the other conditions as described by Foot (1972) are met, ice formation on conductors should be forecast if the wet-bulb temperature is close to 0 °C.

Acknowledgement

Thanks are due to the Chief Engineer's Department of MANWEB for details concerning the damage to their overhead conductors.

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A note concerning progress and plans for the establishment of operational networks of quantitative weather radars

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Summary

An account is given of work now being undertaken throughout the world on merging data from several quantitative weather radars in order to provide an operational service to a wide variety of users. Some mention of future plans is made when these are known to the author.

The uses to which quantitative radar data may be put are wide-ranging, including both operational and research applications (Bussell *et al.* 1978, Browning 1978). The accuracy with which a radar may measure rainfall amounts has received particular attention over the last decade. Recently, however, the emphasis has moved towards the implementation of a number of quantitative weather radars working together as a network. This note contains a summary of the work currently being undertaken throughout the world on the merging of data from more than one quantitative weather radar for the purpose of providing an operational service to a variety of users ranging from hydrologists to those concerned with weather forecasting for aviation. Some mention of future plans, where they are known to the author, is also included. Most of the information in this note was gleaned when the author attended the Symposium/Workshop on Digital Radar Reflectivity Processing with Applications to Hydrometeorology held in Edmonton, Alberta, Canada, from 15 to 18 October 1979*. The countries mainly involved in developing radar networks are noted below. Some work, particularly in eastern Europe, was not discussed at the Edmonton Symposium, and will not be described in detail here.

Canada. An operational network of C-band (5·6 cm wavelength) radars has been installed, using software and hardware technology developed over the last 20 years by the Physics Department, McGill University, Montreal. This network covers the more highly populated parts of southern Canada. By the beginning of 1980 users will be able to dial in to the individual radar systems to obtain data in real time. During the next decade it is intended to expand the network and replace the older existing radar systems (a technique of deriving rainfall information from geostationary satellite data (Lovejoy and Austin 1979) will also be introduced operationally). It is likely that the interchange of radar data across the US–Canadian border will be given some consideration during the next few years. It is planned to devote considerable effort during the 1980s to the development of applications software and to the education of users of the new products.

Japan. The first of a new generation of quantitative weather radars came into operational use in 1977 at Mount Akagi under the control of the Japanese Ministry of Construction, who have supervised the installation of two further systems which began operation during 1979 (at Mount Shaka and Mount Mitsutoge). During the summer of 1979 data from two of the radars were merged in real time to form a composite picture which could be displayed on a colour display system. The intention is to install over the next decade a national radar network consisting ultimately of about 16 radars.

United Kingdom. Work with quantitative weather radars is centred upon the Meteorological Office Short-Period Weather Forecasting Pilot Project (Browning 1977) and the North West Weather Radar

* The proceedings of the Symposium/Workshop may be published during 1980.

Project (Collier *et al.* 1980). This work is based upon the achievements of the Dee Weather Radar Project (Central Water Planning Unit 1977), and work carried out at the Royal Signals and Radar Establishment (Ball *et al.* 1976, 1979). A research network of four weather radars has been established, and data from these radars have been merged in real time and displayed on a colour interactive display system for use by a team of forecasters (Collier 1979). The philosophy underlying this system, known as the FRONTIERS (Forecasting Rain Optimized using New Techniques of Interactively Enhanced Radar and Satellite) strategy, has been described by Browning (1979).

United States. There are some 70 operational weather radars in the United States at the present time. Of these only four are fully digitized, following the work carried out in the D/RADEX (Digitized RADar EXperiments) Project (McGrew 1972, Saffle 1976). The plan to digitize the remaining radars, known as RADAP (RADar Analysis Project), involves the placing of a commercial contract during 1981–82 (NOAA 1978). A project, similar to the UK Short-Period Weather Forecasting Pilot Project, and known as HRAP (Hydrologic Rainfall Analysis Project), is currently being formulated. This Project is aiming to bring together rain-gauge, radar and geostationary satellite data in near real time, either via the existing National Weather Service AFOS (Automation Field Operations and Services) (Klein 1976) communications network, or, more likely, via river forecast centres at a central compositing computer.

Federal Republic of Germany. A C-band radar has been in operation at the German Weather Service Meteorological Observatory, Hohenpeissenberg (Upper Bavaria) since 1974, as part of a research program (Anderl *et al.* 1976) similar to the Dee Weather Radar Project. During 1980 the intention is to bring into operational use a network of seven radars. Data from these radars will probably be merged to produce three composite pictures every ten minutes, one covering the north of the country, one the central part of the country, and one the south of the country.

Other countries. Sweden has a network of radars which it is planned to update in the near future. Several countries in eastern Europe, notably the Soviet Union (Chernikov 1976) and Poland (Kawecki 1977) have established weather radar networks over the last decade, although most of the radars are not being used quantitatively. Plans to interchange data between east European countries have also been formulated (Ziemann 1973).

From the above it is clear that there is a lot of activity in the implementation of quantitative weather radar networks in many countries. In certain countries, notably Japan and Canada, plans for the operational use of quantitative data from a radar network are well advanced, and data are already being made available to a variety of users on a fully operational basis.

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The use of satellite pictorial data in weather forecasting

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Summary

The Central Forecasting Office of the Meteorological Office uses pictorial data from both polar orbiting and geostationary satellites to help the forecaster in the production of more accurate representations of pressure and humidity fields and frontal positions by means of analyses of clouds and cloud systems. The data can also be used to provide running checks on how well numerical forecasts are performing in the first 6 to 12 hours.

1. Introduction

Meteorologists have been using satellite pictorial data for a number of years as aids for analysing synoptic and smaller-scale weather features. Their use and importance have increased with the continued improvement of satellite instrumentation and because of the extra dependence placed on them following the reduction in the number of ocean weather stations making surface and upper-air observations.

In regions where more conventional types of surface and upper-air observations are few or lacking (i.e. oceanic areas away from the main shipping routes) satellite pictures may at times provide the only current or recent evidence on a particular weather system.

The analysis and forecast areas for the coarse-mesh version of the Meteorological Office 10-level model cover much of the northern hemisphere. The Meteorological Office provides forecast information for many parts of the northern hemisphere and it is thus important that the basic analysed fields are the best possible for the whole area. Numerical forecasts are computed routinely for periods up to six days ahead and sometimes the longer-term predictions for the British Isles area may depend significantly on initial analyses for quite distant areas. Satellite pictures for all parts of the northern hemisphere are thus of potential importance to the work of the Central Forecasting Office (CFO).

2. Pictorial satellite data available

Pictorial satellite data used in CFO fall broadly into five categories:

1. Visible and infra-red data from the US polar orbiting satellites TIROS N and NOAA 6 received in near real time (received at Lasham and relayed to Bracknell).
2. Visible and infra-red data from the ESA geostationary satellite Meteosat* received in near real time (relayed from Lasham to Bracknell).
3. Visible and infra-red data from the GOES E geostationary satellite at 75°W and from the GOES INDIAN OCEAN geostationary satellite at 58°E received in near real time (relayed via Meteosat through Lasham to Bracknell).
4. Visible and infra-red data from orbiting and geostationary satellites (mostly in mosaic form) received over normal international meteorological facsimile networks from various parts of the world. These include data on tropical storms (not in real time).

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* This article was written before the failure of Meteosat in late November 1979.

5. Composite mosaics derived from visible and infra-red data from the US polar-orbiting satellites received by Lasham. These are prepared in the Meteorological Office Systems Development Branch (Met O 22) in near real time.

Figure 1. Approximate area from within which satellite images from TIROS N and NOAA 6 can be received at Lasham.

TIROS N and NOAA 6

Continuously broadcast signals from an orbiting satellite can be received at a station on the earth's surface while the satellite remains above the horizon from the receiving point. In the case of TIROS N and NOAA 6, orbiting on tracks passing close to both north and south poles at respective heights of approximately 870 and 830 km, the area of the earth's surface which may be surveyed using signals received at Lasham in real time is approximately that shown in Figure 1. This area comprises much of Europe (including the British Isles), Scandinavia, North Africa, Iceland, east Greenland and a large part of the Atlantic of middle and northern latitudes. This is the area probably of most interest to forecasters when forecasting for the United Kingdom for periods of 24–36 hours ahead. Each satellite

scans the area twice daily with three (sometimes four) successive satellite passes, each pass occurring about 25° of longitude further west and 102 minutes later than the previous one. Since the satellite does not complete an integral number of orbits in a day the tracks do not repeat on a daily basis although the local solar time is essentially unchanged for latitude crossings. Spatial resolution is about 4 km in both visible and infra-red channels. On-board satellite processing of the imagery produces a linearized picture, i.e. reduces the crowding of lines of longitude towards the picture edges evident with earlier satellites.

Sectors of these pictures showing particular areas on a larger scale (in the Meteorological Office case, the British Isles area) are also available. Picture resolution for these is about 1 km in both visible and infra-red channels. Central Forecasting Office analysts add grids of latitude and longitude to the satellite pictures using an overlay appropriate to the notified orbit characteristics.

Meteosat

Geostationary satellites, of which Meteosat is one, orbit the equator at a height of 35 000 km remaining effectively above the same point on the equator (0°E for Meteosat) from which they continuously view the same area of the earth's surface.

For Meteosat thermal infra-red data the disc viewed is divided into nine roughly equal areas, D1 to D9 (see Figure 2(a)), D2 being the most important format for analysing the western Europe/east Atlantic sector.

For Meteosat visible data the disc is subdivided into 24 areas, C1 to C24 (see Figure 2(b), formats C2 and C3 being the most important for the western Europe/east Atlantic sector. Coast lines and grids of latitude and longitude are superimposed on most formats by the ESA station at Darmstadt. Meteosat has the facility to provide at very frequent intervals both infra-red and visible pictures for particular D and C formats which can be particularly useful for tracking such features as rapidly moving waves in a jet stream for instance. Drawbacks are the oblique view that is taken of the earth in higher latitudes (e.g. northern Europe and North Atlantic) and image resolutions inferior to those of the polar-orbiting satellites.

Meteosat also transmits image data in the water vapour absorption band on formats E1 to E9 (E1 covering the same area as D1 etc.; see Figure 2(a)) which are representative of the humidity of the middle troposphere (600–300 mb). Image data from the US GOES geostationary satellites at 75°W and 58°E are also relayed to Bracknell via Meteosat.

Miscellaneous

Other miscellaneous satellite pictures and composite mosaics are relayed from various national sources via the international facsimile networks. These are usually some hours old when received and because of transmission and reception conditions lack the gradations of shade from black to white obtained with pictures received in real time via Lasham.

TIROS N and NOAA 6 composite displays

Signals from TIROS N and NOAA 6 are also relayed to the Meteorological Office Systems Development Branch where a composite picture is prepared from the three or four passes received at Lasham. The pictures are merged where they overlap and are reproduced on a $1{:}20 \times 10^6$ polar stereographic chart to which lines of latitude and longitude and coastlines are added. The fact that this is on the same scale and projection as the Senior Forecaster's chart allows direct comparisions to be made using a light-table.

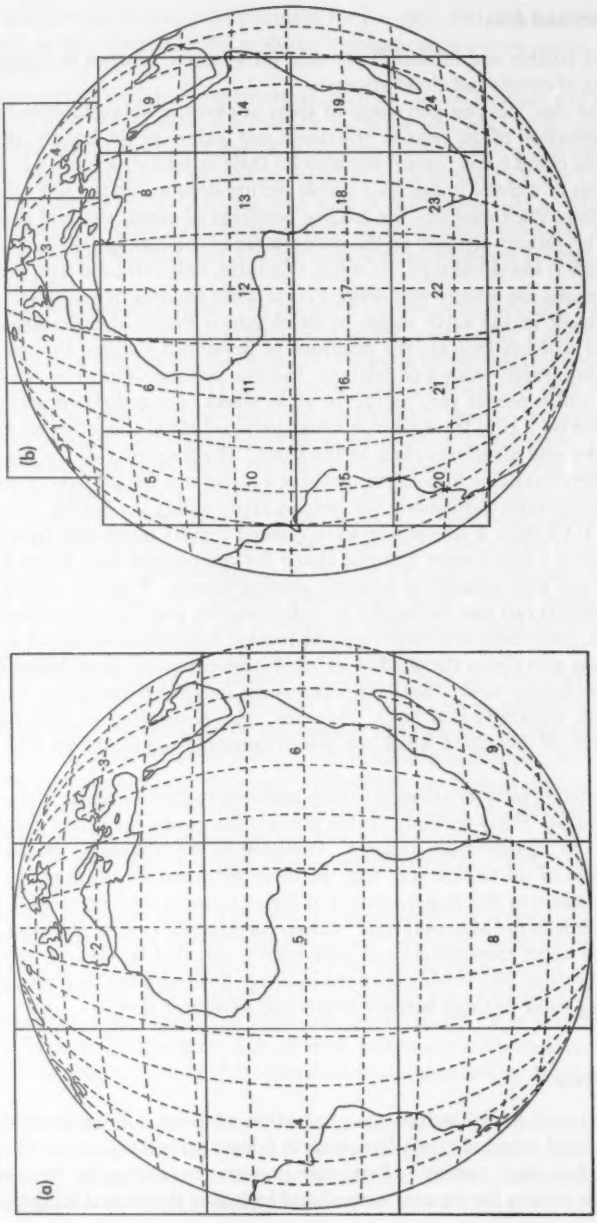


Figure 2. Area viewed by Meteosat: (a) infra-red—9 subdivisions (b) visible—24 subdivisions.

3. The use of satellite pictorial data

Satellite pictorial data (visible and infra-red) are used for synoptic analysis in a somewhat indirect way through the analysis of clouds and cloud systems.

As well as showing the size, location and shape of areas of cloud, visible and infra-red satellite pictures can, from an examination of the relative brightness and texture of the images, provide not only useful information on the cloud types present but also on their vertical structure on both synoptic and smaller scales. Brightness of a cloud image on a visible picture depends on the sun's illumination, the reflectivity (related to cloud thickness) and the relative positions of cloud, sun and radiometer. With an infra-red picture the brightness depends on the temperature of the emitting surface (i.e. the brighter the image the colder (higher) the cloud top). At night, of course, only infra-red data are received.

Cold fronts and occlusions are usually well defined on satellite pictures though warm fronts are not so easily discernible (except in the early stages of development before they become overlain with cirrus). Spiralling cloud patterns indicate the positions of developed vortices though clouds over a depression at the wave stage rarely show a circulation. Satellite pictures often show the development of a wave on a cold front which proves very useful for areas where conventional observations are few. Waves commonly develop on a cold front when a comma-shaped cloud (denoting an area of positive vorticity advection) in the cold air moves close to the front. The frequency of the Meteosat pictures (at hourly or shorter intervals) helps to confirm tentative conclusions drawn from a subjective interpretation of an individual picture, particularly for systems approaching the British Isles from the west and south-west. Plates I–VI show a developing wave moving rapidly north-east from west of Iberia to the British Isles. Figures 3 and 4 show synoptic charts for comparison with Plates I and V respectively. Satellite pictures are also valuable in locating tropical storms. Patterns formed by individual cells (e.g. groups of cumulus) can also be helpful in indicating the position and intensity of synoptic features. Upper troughs, cold pools and ridges may be located from the evidence of satellite pictures and sometimes jet streams also (from the shadow of jet-stream cirrus on cloud below or from cirrus streaming ahead of a developing wave). Satellite pictures are sometimes useful for establishing links between different systems, especially new links. However, care is required as links have sometimes become inactive and bands of low cloud which are not dynamically significant are best omitted from disseminated analyses.

On the smaller scale, satellite pictures are used to help make short-term forecasts of the persistence or dissipation of fog and stratus. Early-morning visible pictures can reveal the extent and boundaries of fog and stratus common to high-pressure systems. Variation in the brightness of the top of visible pictures gives an indication of the thickness of fog, the more persistent areas appearing the brightest. Satellite pictures are also useful in deciding the extent of fog and stratus over sea areas.

Limited use has been made of the Meteosat water vapour formats (E1 to E9). On these, white regions indicate a relatively moist upper troposphere and dark regions one that is relatively dry. Some inferences may be made of the rising and sinking motions in upper flows and the pictures have sometimes been useful for delineating weak linkages between fronts and jet-stream flow.

4. Relative humidity analyses

The functions of the 10-level model include the production of forecast fields showing the expected rate of rainfall (mm/hour) and expected rainfall amounts in 6-hour periods (mm) over the areas covered by the coarse-mesh and fine-mesh versions. Particular importance is attached to rainfall forecasts produced by the fine-mesh version for the area around and including the United Kingdom.

Objectively analysed fields of relative humidity for the 1000, 850, 700 and 500 mb levels are produced by the computer to provide the model with the necessary data on the initial moisture content of the lower troposphere.

Over meteorologically well-documented areas, such as Europe, surface and radiosonde observations provide sufficient data for an adequate relative humidity analysis. Over large sea areas, it is often difficult to form an adequate relative humidity analysis from the few widely spaced radiosonde ascents available. It is often particularly important for rainfall forecasting for the United Kingdom that the relative humidity analysis for the Atlantic area west of the British Isles be as accurate as possible. In the Central Forecasting Office an attempt is made to supplement the small amount of conventional observational data available from the Atlantic area with assessments of relative humidity made from satellite pictorial data.

The pair of orbiting satellite visual and infra-red pictures covering the UK and the Atlantic area west of the British Isles received during the morning is used as the guide for the 12 GMT relative humidity fields. Such a pair can provide a useful indication of the areas and levels of highest and lowest humidity. At night, for the 00 GMT analyses, satellite guidance can only come from the infra-red pictures, so daytime necessarily is the main time for humidity analysis modification. Meteosat pictures close to the main observation time may provide supplementary information.

Normally, the shapes of cloud areas are transferred manually from the satellite pictures to a copy of the Senior Forecaster's latest working chart (for midday humidity modification the 06 GMT chart is usually used). On this is indicated the estimated horizontal and vertical extents and thicknesses of cloud (height crudely estimated as high, medium or low). This is done in conjunction with available surface observations (since rain-bearing clouds may be overlain by extensive cirrus) making allowance for differences between chart and satellite observation times. When considering relative humidity analyses for the 10-level model, 500 mb is normally taken as the level for cirrus, 700 mb for medium-level cloud and 850 and 1000 mb for low cloud and fog.

The analyst will check that the positions of the areas of high and low relative humidity on the background field (i.e. the 12-hour forecast of relative humidity which is used as a first guess to the analysis) are consistent with what is shown by the satellite pictures and that the values of relative humidity themselves seem to be of the expected order. If there are inconsistencies, he has two courses of action. He can alter the background field, displayed as isopleths on a visual display unit (VDU). These isopleths can be altered to fit the preferred analysis (superimposed on a plastic overlay) by using a light-pen, the final amended analysis then being fed back to the computer. Alternatively, invented values of relative humidity for particular positions (bogus observations) may be fed to the computer to produce the required analysis.

Choice of values of relative humidity to use is a very subjective process. Estimates are usually made to the nearest 5 or 10 per cent, the aim being to give a reasonable three-dimensional description of the humidity structure in a particular system rather than aiming for precision at a particular level. Particular attention is devoted to systems that are thought to pose a possible chance of bringing rain to the United Kingdom area within the following 24–48 hours. It is generally considered unwise to adopt values as high as 100 per cent. Use of these values at successive standard levels lying in cloud could imply a thick column of totally saturated air which may not be representative of the column as a whole.

It has been found best to use values usually no higher than 85–90 per cent and rely on vertical motions computed by the model and typical of rain-producing systems to achieve the levels of saturation required for rainfall. (Radiosonde ascents rarely indicate 100 per cent relative humidity over columns of great extent, even in rain-bearing conditions.)

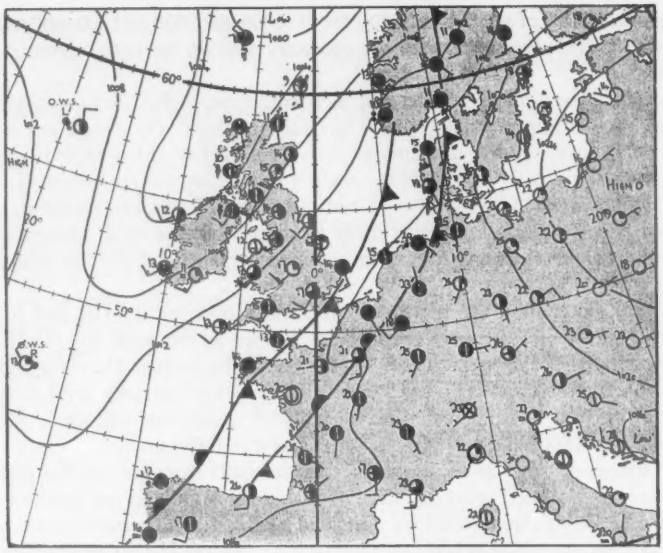


Figure 3. Surface synoptic chart for 18 GMT, 29 May 1979.

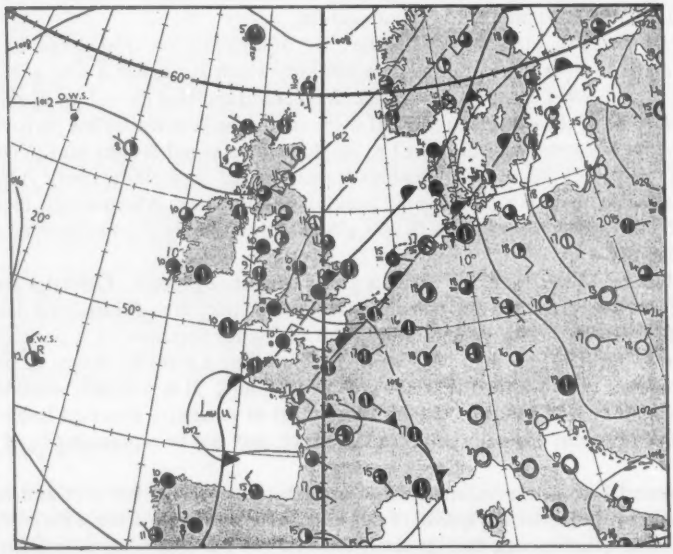


Figure 4. Surface synoptic chart for 06 GMT, 30 May 1979.

To face page 84

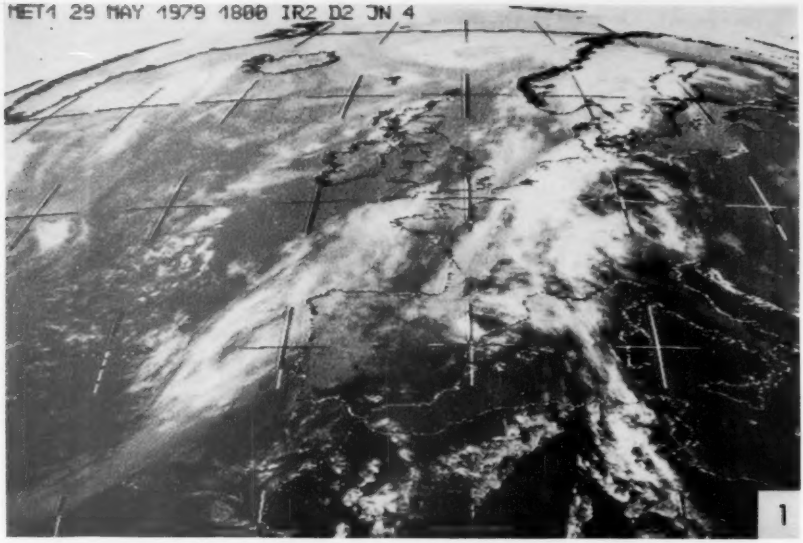


Plate I. Meteosat infra-red image for 18 GMT, 29 May 1979 (see page 82).

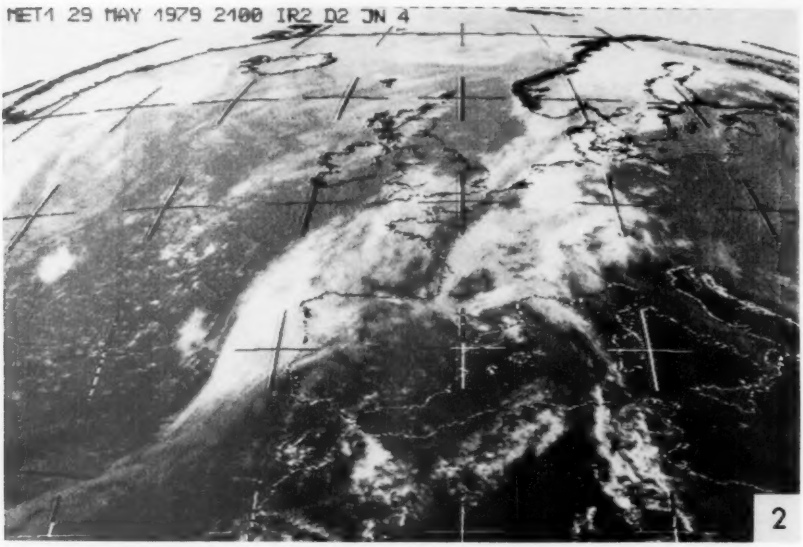


Plate II. Meteosat infra-red image for 21 GMT, 29 May 1979.

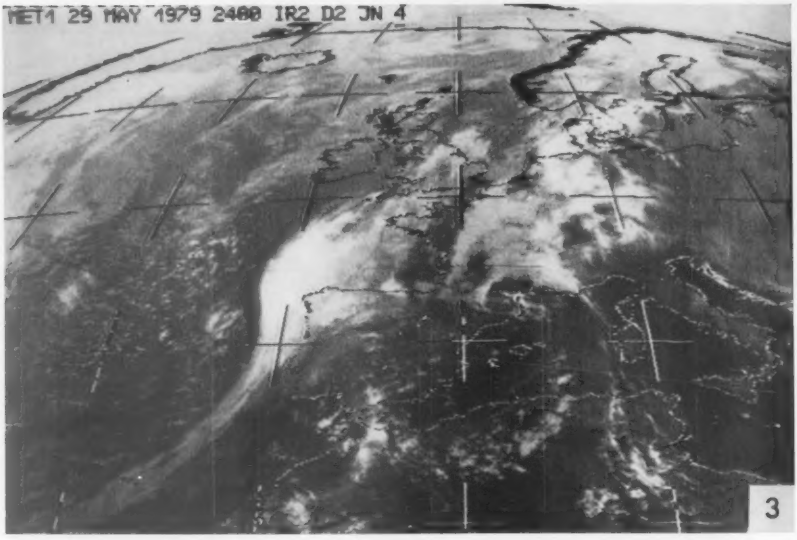


Plate III. Meteosat infra-red image for 00 GMT, 30 May 1979.

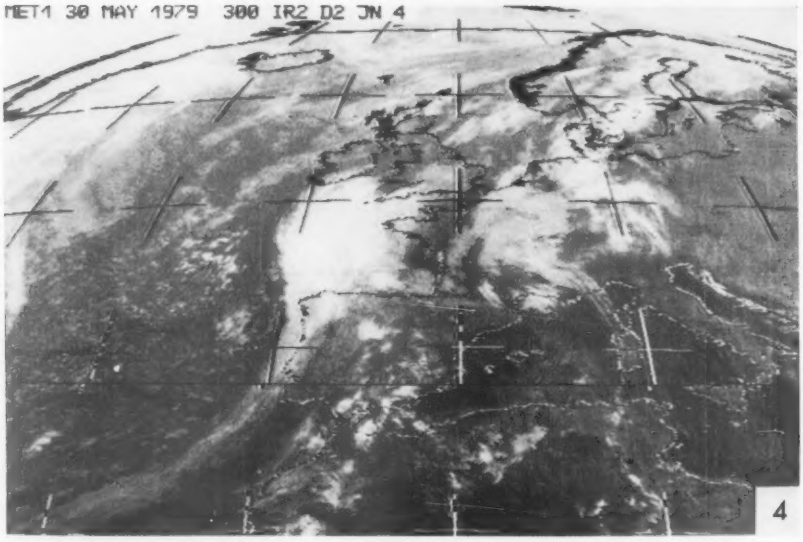


Plate IV. Meteosat infra-red image for 03 GMT, 30 May 1979.

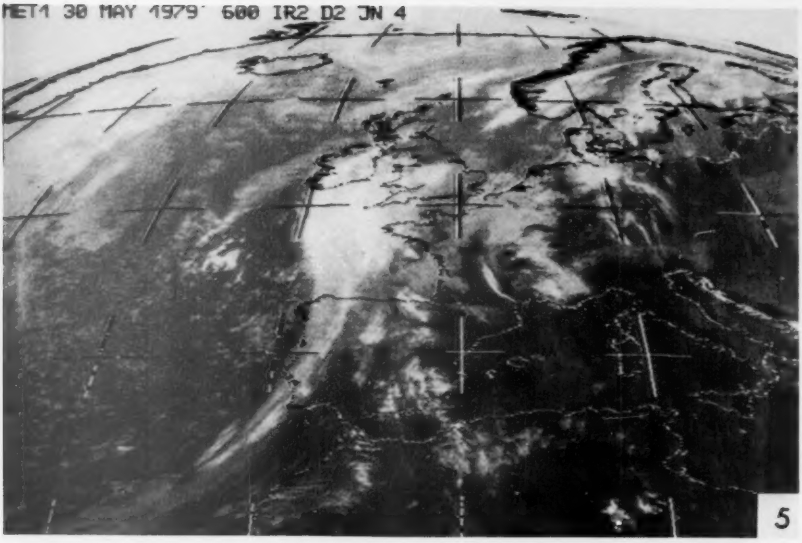


Plate V. Meteosat infra-red image for 06 GMT, 30 May 1979.

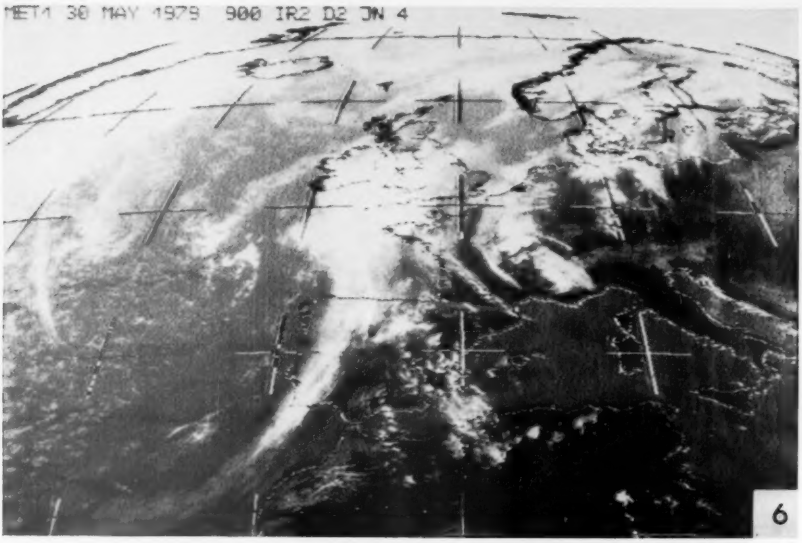
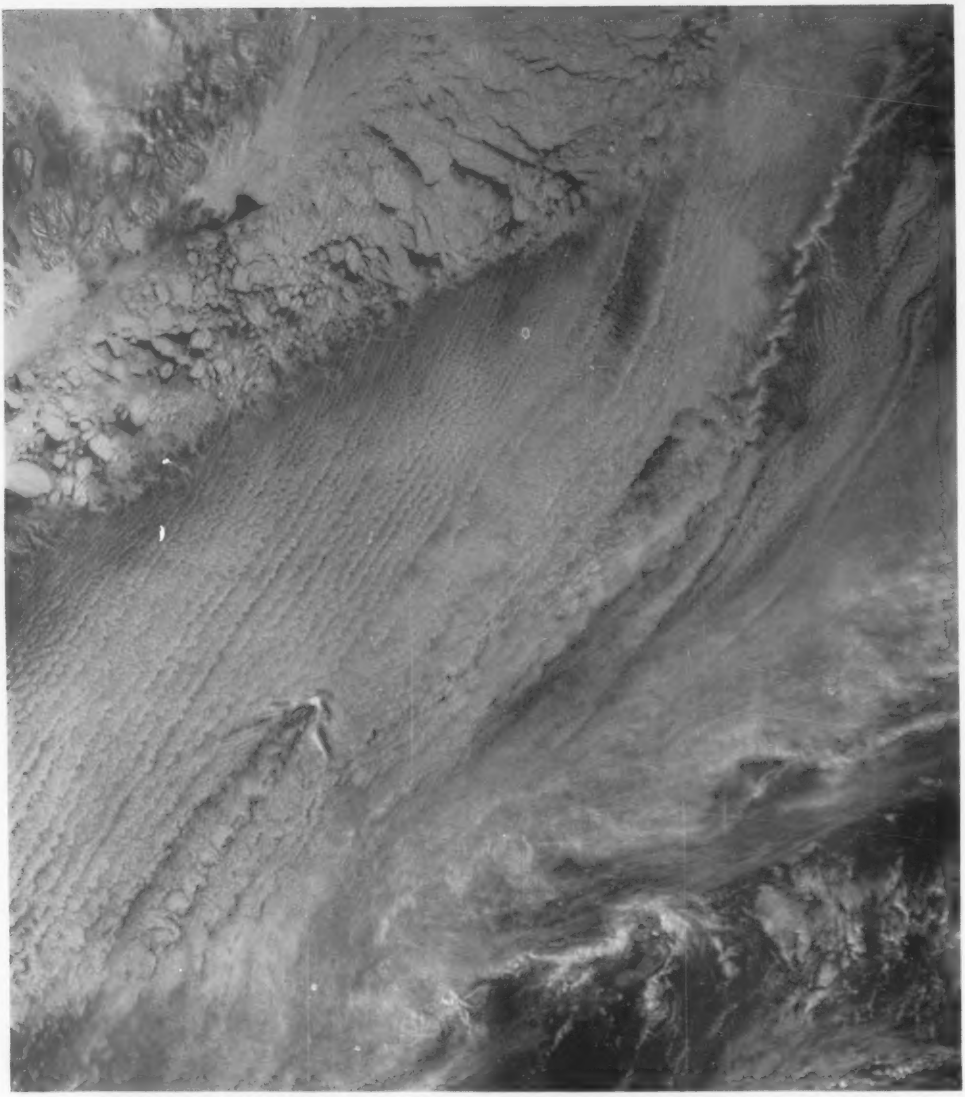
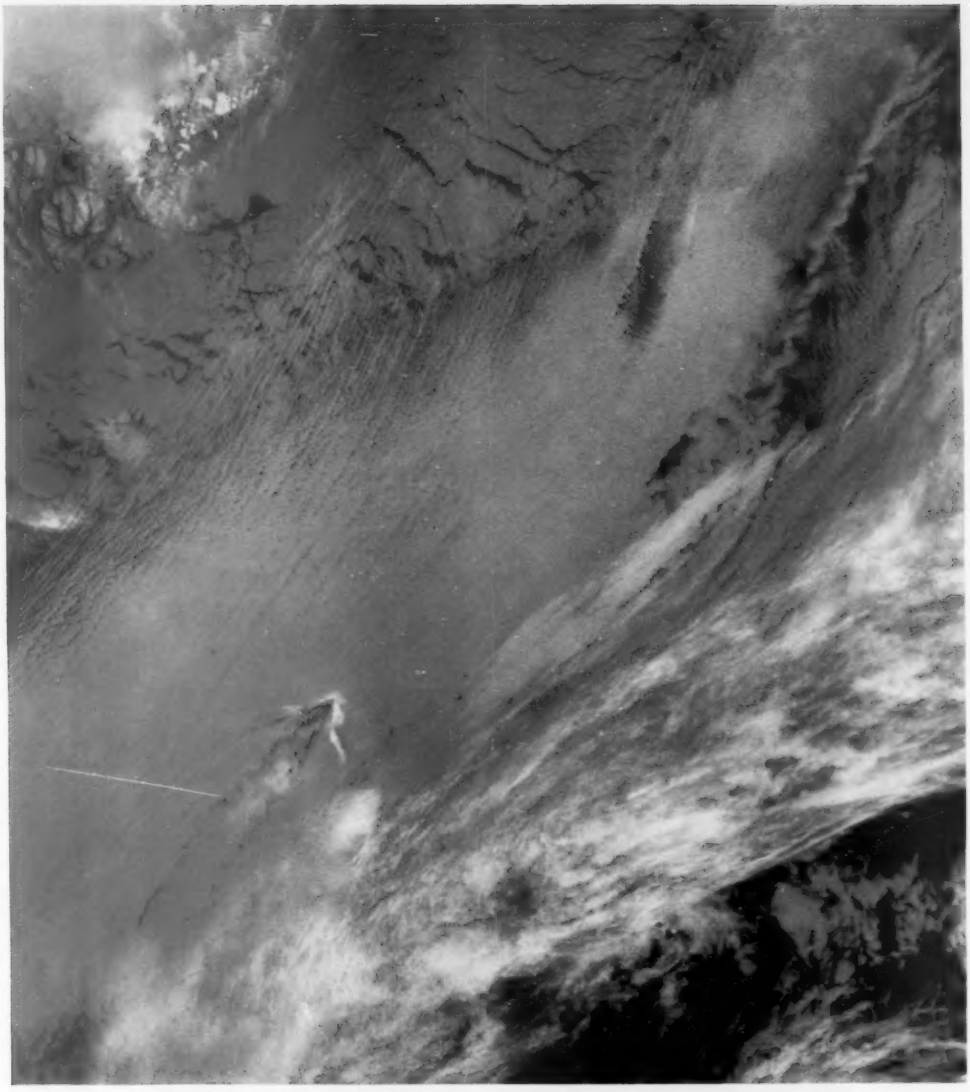


Plate VI. Meteosat infra-red image for 09 GMT, 30 May 1979.



Photograph by courtesy of Dundee University.

Plate VII. Visual image received from TIROS N satellite at 1407 GMT, 29 April 1979. The cloud resembling a ship's bow wave locates Jan Mayen Island; large ice floes are seen off the east coast of Greenland with pack ice to the north, and at the top right there is a shear rope cloud. (See page 85.)



Photograph by courtesy of Dundee University.

Plate VIII. Infra-red image from TIROS N satellite for the same time as the visual image shown as Plate VII.

Plate IX. L. G. Groves Memorial Prize and Award winners with Mr Nicholas Abbott, Air Marshal Sir John Nicholls and Air Commodore K. W. Hayr. Seated left to right: Mr Nicholas Abbott, Air Marshal Sir John Nicholls, K.C.B., C.B.E., D.F.C., A.F.C., and Air Commodore K. W. Hayr, C. B. E., A.F.C. Standing left to right: Flight Lieutenant J. S. Garnons Williams, Mr D. E. Miller, and Flight Lieutenant J. Holland. (See page 88.)

Plate X. Mr Nicholas Abbott and Mr D. E. Miller, winner of the Meteorology Prize.

Plate XI. Mr Nicholas Abbott congratulates Flight Lieutenant J. Holland, winner of the Meteorological Observer's Award.

Plate XII. Mr Nicholas Abbott presenting the Second Memorial Award to Flight Lieutenant J. S. Garnons Williams.

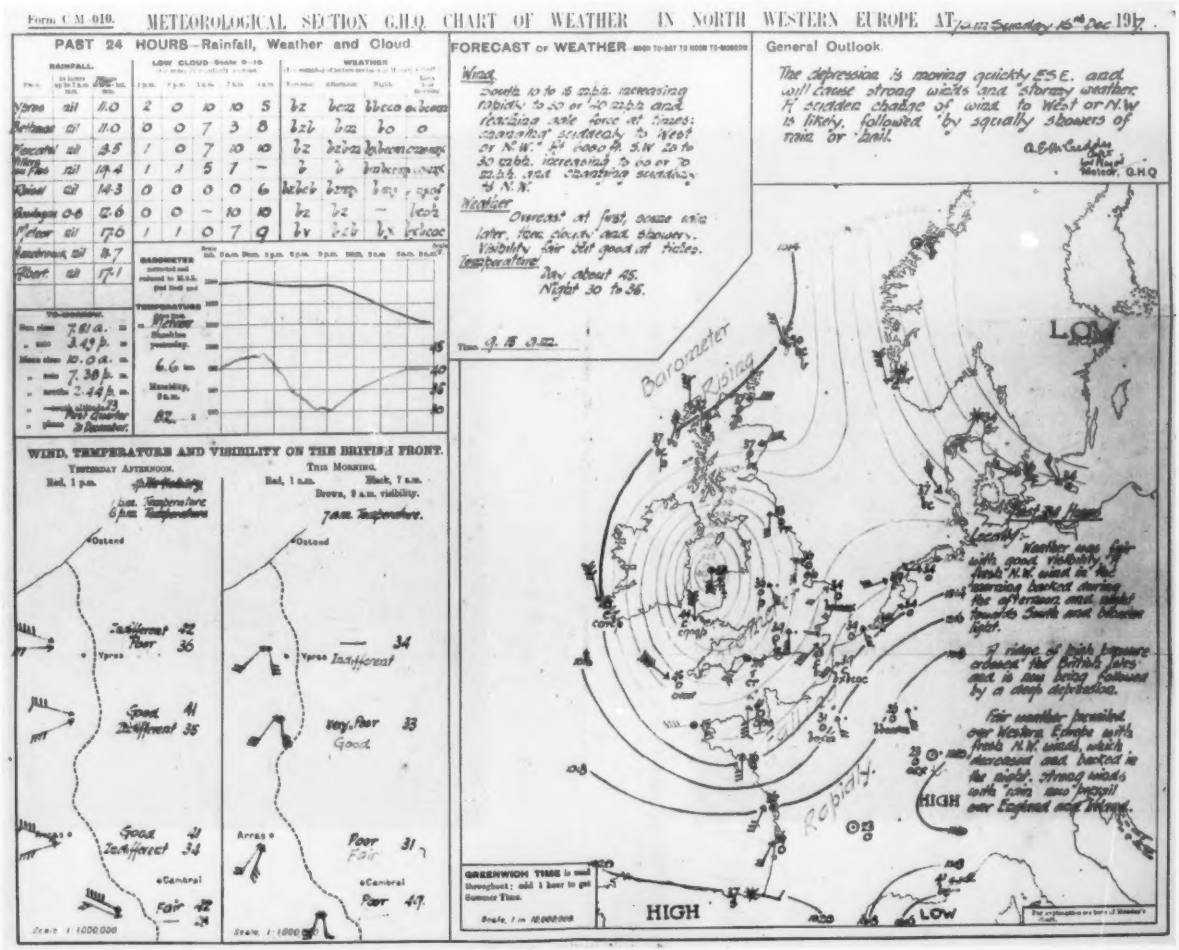


Plate XIII. See page 95.

5. Assessment of fine-mesh forecasts

Satellite pictures, especially those from Meteosat, are sometimes useful in judging whether the evolution of the fine-mesh rainfall forecasts is likely to be successful. Usually, the Senior Forecaster, during the early afternoon when preparing his forecasts for the following day, relies for guidance on numerical data based on the previous midnight's observations (output based on 12 GMT data not being available until later in the afternoon).

The fine-mesh version produces forecast fields (including rate of rainfall) for the Atlantic/western European sector for 06, 12 and 18 GMT on that day together with forecasts for 00, 06 and 12 GMT the following day.

The forecaster can compare the forecast rate of rainfall field for 12 GMT on the first day with the cloud patterns shown on satellite pictures for near that time (usually Meteosat 11 or 12 GMT, whichever is available).

If the forecast rate-of-rainfall field seems consistent with the estimated area of rainfall from the satellite picture, extra confidence will probably be felt in the subsequent stages of the fine-mesh forecast. Significant differences may be attributed to:

(i) timing errors in movement or development of the synoptic pattern;
(ii) errors in forecasting the extent and intensity of rain.

It may then be possible at times with knowledge of the above to make a subjective modification and improvement to the later stages of the forecast.

Similarly, it is sometimes possible to compare the positions of identifiable synoptic features from the 12 GMT Meteosat pictures (lows, cold pools, troughs etc.) with their forecast position for the same time on the corresponding fine-mesh forecast, when only few or no synoptic observations for that time have been received. Again, this sometimes allows a successful modification (e.g. timing adjustment) to be made to the later stages of the forecast.

551.507.362.2:551.576.1

Interesting cloud formation seen on satellite imagery

By N. J. Atkins

(Meteorological Office, Bracknell)

Summary

Two interesting cloud phenomena seen on one satellite picture are briefly discussed and related to the weather situation at the time.

Introduction

Plate VII shows a satellite (TIROS N) visual image received at 1407 GMT on 29 April 1979 and the corresponding infra-red image is seen on Plate VIII. Near the centre of the pictures is a cloud formation which has the appearance of a ship's bow wave, and this locates Jan Mayen Island. At the top right of each photograph there is a long twisted cloud best described as looking like a piece of rope.

Synoptic situation. On 29 April 1979 a depression to the south-east of Jan Mayen moved slowly eastward and with pressure building over eastern Greenland a strong northerly airstream covered a large area by midday (see Figure 1). At 12 GMT the Jan Mayen weather station (29 ft above mean sea level) reported a total cloud cover of stratus with base between 200 and 300 m (600–1000 ft), a northerly surface wind of 45 knots, air temperature −5 °C, dew-point −10 °C and visibility 100 m in heavy blowing snow (i.e. above eye level). There was no radiosonde release at midday but the ascent at 00 GMT (see Figure 2) represents the northerly airstream in early stages of development. The air is stable, suggesting the formation of turbulent stratus and stratocumulus in a strong airflow.

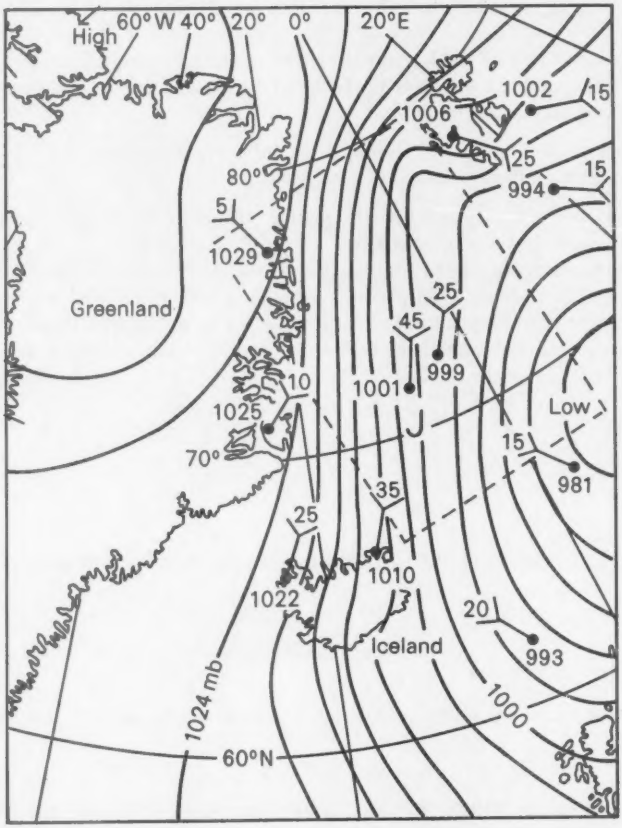


Figure 1. Surface analysed chart for 12 GMT, 29 April 1979 showing a strong northerly airstream over Jan Mayen Island (J). The area contained by the dashed lines is approximately the same as seen on the satellite pictures in Plates VII and VIII. Plotted observations show mean-sea-level pressure in millibars and wind speeds in knots.

The bow wave cloud. Wave clouds caused by obstacles are a reliable source of information on airflow direction in the lower and middle troposphere (WMO 1973, p. 219). If the obstacle is elongated the waves are usually aligned perpendicular to the direction of oncoming flow. Wave clouds formed by isolated islands, such as Jan Mayen, which is a volcanic island with the highest peak (Beerenberg) 2276 m (7469 ft), assume the appearance of a ship's bow wave spreading out on the leeward sides of the high ground. The direction of flow coincides with the bisector of the angle at which the wave clouds diverge. In the example illustrated the brightness of the wave cloud on the infra-red image (Plate VIII) indicates a higher cloud top due to forced lifting of the air mass up the mountain sides and the deeper cloud then flowing out along the wave. The shadow of the wave cloud can be seen on the visual picture (Plate VII).

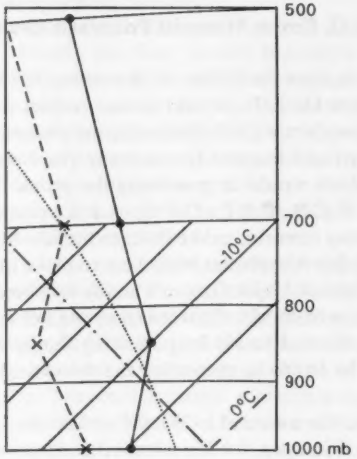


Figure 2. Radiosonde ascent from Jan Mayen at 00 GMT, 29 April 1979.
·——· dry-bulb temperature; × – – – × dew-point temperature;
—· —· dry adiabatic; ···· saturated adiabatic.

The shear rope cloud. A long spiral-like formation of cloud looking very much like a piece of heavy rope. The one seen in Plates VII and VIII is well shaped for a distance estimated to be about 150 miles. This type of cloud indicates turbulence and usually occurs in cold air; it does not require an upwind obstacle but a condition for its formation is a marked horizontal wind shear (Air Weather Service 1969, p. 5-D-3). A low-level wind shear is evident in this example (see Figure 1). The term shear rope cloud is used to differentiate it from rope clouds associated with tornadoes (Scorer 1972, p. 159).

Acknowledgement. I have to thank the Electronics Department of the University of Dundee for making the TIROS pictures available to me and it is with the University's kind permission that the photographs are reproduced.

References

Geneva, World Meteorological Organization 1973 The use of satellite pictures in weather analysis and forecasting. *Tech Note* No. 124.

Scorer, R. S. 1972 Clouds of the world. Newton Abbot, David & Charles.

Washington, Air Weather Service, United States Air Force 1969 Application of meteorological satellite data in analysis and forecasting. *Tech Rep* 212.

Awards

L.G. Groves Memorial Prizes and Awards

The annual award of prizes took place on Friday 30 November 1979 at the Main Building, Ministry of Defence, Whitehall (see Plates IX–XII). It was in one respect a sad occasion because since the previous prize-giving Major Groves himself had died; everyone present, however, was glad that the work he and Mrs Groves had initiated and inspired for so many years was being carried on and that his great-nephew, Mr Nicholas Abbott, would be presenting the prizes. The Vice Chief of the Air Staff, Air Marshal Sir John Nicholls, K.C.B., C.B.E., D.F.C., A.F.C., presided.

Sir John Nicholls, in his opening remarks, paid tribute to the late Major Groves and to Mrs Groves. He said how pleased he was that Mr Abbott was with them to make the presentations, and he was glad to see that so many other members of Major Groves's family had been able to attend.

Mr Abbott then read a message from Mrs Groves expressing her regret that owing to ill-health she was unable to be present. He referred to his long-standing family connections with the Royal Air Force, and said how honoured he felt to be presenting the prizes now that, sadly, his great-uncle was no longer there.

The 1979 Aircraft Safety Prize was awarded to Wing Commander H. W. Hughes, now serving with the Canadian Armed Forces in Winnipeg, for his proposal to improve the Canberra PR7 emergency warning system, with the following citation:

'Most aircraft in current RAF service are equipped with a standard warning system which monitors the important aircraft systems and presents the crew with an audible and visual warning when a failure occurs. However, because of their early design, Canberra aircraft do not have such equipment. Royal Air Force Canberra PR7 aircraft are employed primarily in the tactical reconnaissance role and the crew have to spend the majority of their time looking outside the cockpit for terrain avoidance, low-level map reading, target acquisition and reporting. Therefore, an airborne emergency could develop to a serious degree before the aircrew would be alerted by the warning lights in the cockpit. Wing Commander Hughes's proposed modification to remedy this flight safety hazard re-routes the engine fire warning, the engine fuel low-pressure warning and the generator warnings and connects them in parallel to the cabin pressure warning circuit, which is fitted with a warning horn. Thus, if one of these vital systems were to fail the crew would receive timely audio and visual warning enabling them to take action before the situation worsened.'

Wing Commander Hughes was unfortunately unable to be present to receive his prize in person.

The 1979 Meteorology Prize was awarded to Mr D. E. Miller of the Meteorological Office with the following citation:

'Mr D. E. Miller has been a pioneer in the application of satellites to meteorology. In recent years, as a consultant to the European Space Agency and member of various working groups, he has made many contributions to the development of the Meteosat system. In particular, he has been concerned with the design of the computer-based system which transforms the raw data from the satellite into usable pictures and other meteorological products. He has also been the leader of the team which has developed an instrument for measuring temperatures in the stratosphere from the TIROS-N series of satellites, the first two of which have been launched successfully in the past year.

'His deep understanding of the scientific problems, coupled with a sound appreciation of the need to obtain practically useful results and an energetic and painstaking attention to detail in overcoming difficulties, have made him an outstanding member of the teams working on these two projects and contributed greatly to their success'.

The 1979 Meteorological Observer's Award was awarded to Flight Lieutenant J. Holland, now at Royal Air Force Odiham, with the following citation:

'Flight Lieutenant Holland joined the Meteorological Research Flight (MRF) in August 1975 and was posted out in April 1979. During this time, as well as being a first-class navigator, he readily identified himself with the special requirements of MRF project flying and also made valuable contributions to the preparation of the various Trials Instructions. His calm approach in all aspects of the work was always a tower of strength, particularly so on projects such as the JASIN (Joint Air–Sea Interaction) experiment where several—sometimes foreign—aircraft were also involved within a limited airspace, and accurate navigation was at a premium.'

The 1979 Second Memorial Award was awarded to Flight Lieutenant J. S. Garnons Williams of Royal Air Force Shawbury with the following citation:

'The danger of a wirestrike is an ever present hazard in helicopter operations and military helicopters, which spend much of their time at low level, are particularly at risk. Moreover, we are likely to see an increase rather than a decrease in low-level helicopter operations in the future. While considerable effort has been devoted to solving the birdstrike problem for fixed-wing aircraft, little research has been devoted to the similarly hazardous and costly problem of helicopter wirestrikes. Flight Lieutenant Garnons Williams has proposed a simple wire-cutter that would protect the aircraft—apart from the main rotor—against all but the thickest power cables at speeds as low as 30 knots. The advent of wire-guided anti-tank missiles has added a new dimension to the helicopter pilot's problems since any future battle area will be festooned with fine wire. It is possible, therefore, that Flight Lieutenant Garnons Williams's idea may prove operationally valuable as well as reducing the peacetime cost of wirestrikes.'

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Memoirs of an Army Meteorologist

By H. Cotton, M.B.E., D.Sc.

Part 6

A few days after the German push had failed and things had settled down again, we made another, and this time final, move. The new site was at Senlecques, a village, very pleasant after those we had been used to, with comfortable brick-built houses and a *place* quite imposing for the size. It was situated on a secondary road, leading west, from the main road through Desvres to Calais. So we were almost as far away from the war as we could be and to all intents and purposes we were doing a civilian job, there being no possibility of alarms of any kind: shelling, bombing, or strafing of the balloon by enemy planes—the great fear of kite balloonists because even if they jumped and the parachute opened, they were likely to be machine-gunned. To the enemy the idea of giving a helpless man a sporting chance was not on. For once Dinkle was delighted since both Calais and Boulogne were an easy run in the light tender and there would be plenty of girls in both places. And so it proved, and needless to say, he was now always short of money. What the reason was for our removal to a place so remote from the war areas I never knew but, needless to say, nobody grumbled.

When we came to Senlecques, such a quiet spot, I thought that there could no possibility of alarms or excitements, but I forgot to take the weather into account. Kite balloons are fair-weather appliances and are not meant to ride out violent storms. After the collapse of the second German offensive there was a period of comparative quiet but, as there was now an almost unlimited supply of guns and ammunition, there was continuous harassment by shell-fire and this, to be effective, necessitated the supply of wind corrections. There was a long spell of stormy weather during which observations of anything above ground level were impossible. The Air Force was grounded and pilot balloons were whisked away as soon as they were released, hardly rising at all. With almost gale-force winds, low scudding clouds and frequent squally showers, the kite balloon was also grounded and so, for a considerable period there were no data of any kind, apart from the surface wind, from which to compute the information required by the artillery. We consequently had nothing to do as the weather was too bad even for walking.

One morning Lieut. West came to me with a face like thunder.

'Wing says that we have to go up now. I told them that it would be suicidal but they said that it was an order from G.H.Q. You'd better ring up G.H.Q. and tell them that it is quite impossible.'

'I can't do that', I said; 'Wing is sure to have told them what conditions are like and, in any case, they have the reports of all the Meteor observers. Quite frankly, with my quite insignificant rank I am not prepared to question the orders of G.H.Q.'

'You mean you are prepared to go up, even in this?'

'I don't see any alternative. After all, millions of men have died already in this war, so why should they bother about two unimportant subalterns? I don't mind telling you I am scared stiff at the idea, but since G.H.Q. have said that we have got to go up, we have got to go up. You are in charge of the

balloon but remember, it has been used solely for the purposes of Meteor, and you must admit that we have had a cushy time. So come on, let's go and get it over. Tell Dinkle to say his prayers for once and pray that we don't break loose and land somewhere in Siberia.'

Dinkle expressed his disapproval in the most picturesque language and the balloon crew thought we were crazy, as undoubtedly we were. Once released from its mooring the balloon was almost unmanageable, the men on the handling guys being dragged backwards and forwards and the basket bumping violently on the ground. I was afraid that when they 'let go the guys'—I didn't laugh this time—a man might be too late and find himself carried into the air as had sometimes happened. Fortunately we were spared that calamity.

Once released from the ground the balloon was in the control of the wind and, at first, it wasn't too bad, but when we had risen about 100 feet it demonstrated what it could do. After all it was a kite, so in addition to the rolling, pitching and shuddering that one experiences on a small boat in a rough sea, it responded to sudden changes in wind velocity, plunging violently downwards when there was a lull and ascending equally violently when the velocity suddenly increased. Stanley Holloway could have written a comic monologue about 'this up and down kind of existence', but to us it was far from funny. The amplitude of these plunges increased the higher we rose and I was surprised to realize that I did not even feel seasick. No doubt it was because I was too scared.

With all the cable paid out by the winch, we reached only 1500 feet, the cable being almost horizontal apart from the sag in it. I had been watching and listening to the metal V by which the balloon was attached to the cable. It was on this that I had to take a compass bearing. I did not like its violent to and fro working for it was not unlike the way one bends an iron bar backwards and forwards in an attempt to break it.

'What do we do if that thing breaks?' I asked, trying to sound nonchalant and feeling anything but.

'What the hell can we do?'

'I know one thing,' I said; 'I am not going to risk jumping; what about you? But of course you can't leave the ship as long as I am here.'

It was obvious that jumping in a wind like that would be suicidal, so there was nothing for it but to stay where we were and hope for the best. Actually the worst was still to come. During the descent the up and down plunges were, if anything, worse than before, as the balloon thought up a new trick which it hadn't used during the ascent. After a little while, in addition to doing all its other tricks, it began to yaw from side to side, only a little at first but the amplitude gradually increasing as the distance between balloon and winch decreased. It soon became clear that the yawing, instead of being a simple oscillation in a straight line, was motion along the arc of a circle and that as the length of paid-out cable decreased the angular extent of the oscillation progressively increased. The sum total of all the motions to which the balloon was subject was impossible to deduce. I forgot all about my fear of breaking loose and, instead, wondered what antics the balloon would be up to when we nearly reached the ground. With only about 50 feet of cable paid out the motion due to yawing was almost a complete semicircle and, whatever we felt, we must have looked damned silly from the ground.

With about 30 feet of cable paid out the tips of the handling guys momentarily just touched the ground and then we immediately set off on one of our semicircular orbits in the opposite direction. It was fortunate that the winch was in the middle of the field so that there were no obstacles of any kind. Soon our basket was bumping on the ground and the balloon crew, Dinkle among them, running like mad from side to side trying to grasp the handling guys. I was afraid that a man might get hold, be afraid to let loose, and be dashed to the ground on the other side. Fortunately this did not happen and the balloon was finally brought under control. As we thankfully clambered out of the basket, Dinkle ran up and said, 'Come and have a drink'. It was, I think, the most sensible thing he ever said.

I did not think that the data I obtained could have been of much value for, apart from rising only 1500 feet, the kite effect prevented an accurate assessment of the height. Actually with a wind of that nature there is little change of either velocity or direction with height, so perhaps the data would have been of some limited use.

The ascent was, without doubt, a most hazardous undertaking and I agreed with West when he said we deserved a medal. Unfortunately there was no V.I.P. watching us.

When it was over I was glad that I had had the experience, but I would not like to have to do it again. An ascent in such a wind had never been made before and has never been made since. On this occasion, at any rate, my job had been far from cushy.

At 11 a.m. on 11 November, the Armistice was signed. The weather was unsettled over much of France, but at Senlecques it was fine, warm for the time of year, and the sun was shining. A message came from G.H.Q. to the effect that the balloon ascents were to continue, and I was glad, for to stay in such a quiet place, doing nothing, would have been intolerable. The two balloon officers were at first inclined to rebel but they quickly realized that with a body of men waiting to go home and with nothing to do, there would soon have been trouble.

In the middle of the morning I went for a long walk and tried to feel elated, but without success. The war had gone on so long, had become almost a way of life, that it was difficult to realize that it had ended at last. So, whereas for everybody else the war had ended, for us the war, such as it was, continued.

Until the Armistice conditions were fulfilled, the Army continued in a state of combat readiness since, until then, the war was not really ended. Finally, there was a general move forward and, to our regret, we had to move forward as well. Our route was in a general easterly direction, through St Omer, Poperhinghe, Ypres, the dreadful landscape of Passchendaele, now shell-torn and pock-pitted but otherwise a featureless desert apart from the straight road running through it. The Passchendaele Ridge looked so insignificant geographically that it was difficult to realize that it could be the cause of such dreadful carnage, that this quagmire, at that time waterlogged by almost unending pitiless rain, was the last thing that would be seen by the legions of men, German and Allied, who died there, victims of forces they did not even understand.

At one place, by the roadside, there was a boot with a splintered shin bone, bleached white and clean as though it had been immersed in a zoologist's tank of tadpoles, pointing accusingly to Heaven as though in mute protest at the unspeakable things God had allowed men to do to one another. I wondered to what kind of man had this pitiful thing belonged.

Our destination was a rather drab little village on the road to Roulers but just west of that town. My billet was a little house in a row of little houses and the mess was in a larger house facing the main road. As we were merely marking time, I remember little about the place; a ruined church with smashed organ whose pipes looked like protruding intestines; sheets of music in archaic notation which today would probably be very valuable but were then scattered all over the place; an empty house with, scrawled on the wall,

Ost oder West
Da Heim ist das best

and this, which seemed to indicate a dumb acceptance of something too big for understanding,

Lernen leiden ohne zu klagen

unlike the British Tommy who also suffered but not with such bovine acceptance. It appeared that the Germans were human after all.

There was a pile of 76 mm shells just outside the mess window, the shell cases of sheet iron because of the shortage of non-ferrous metal owing to our naval blockade. After lunch one day, I was sitting

by the fire, reading. It was a cold, wet day and the 1 p.m. balloon ascent had been most unpleasant. I heard a banging going on just outside the window and when I investigated I found to my horror a small boy sitting on the pile of shells, banging away with a hammer trying to remove a nose cap. I chivvied the boy away and hurried to find Lieut. West, as being the O.C. it was his responsibility. He evidently contacted the right people for the shells were gone the next day. It would have been an irony if we had all been blown up after the war had ended, not by the Germans but by a young souvenir hunter.

We heard of the beginnings of discontent among troops who, now that the war was over, thought that they ought be shipped home straight away. There was no trouble with the balloon crew and I am sure it was because we were still making the three ascents a day.

Late in December I was notified that I was to be demobilized and I received the necessary papers enabling me to return first of all to Montreuil, the G.H.Q. personnel having remained there while practically everyone went east. Very early on a bitterly cold and wet morning I was taken by tender to Roulers station and after an interminable wait, during which I became colder and colder, the train crawled in. I had what had been a first-class compartment all to myself and, if it had been possible, I would have joined a compartment full of troops, if only for the warmth. The windows were broken and the upholstery in shreds; in fact it would have been a disgrace to the then Great Eastern third-class commuter carriages, and that is saying something. I left the train very thankfully at some place whose name I have now forgotten and made my way to what, I think, must have been a hotel before the war. After about 14 hours in a perishingly cold train, with nothing to eat, I was almost overwhelmed by the warmth and it was some time before I became sufficiently accustomed to it to face dinner. Eventually I did, and very welcome it was. I am quite sure it was only the outdoor life of the last three years which enabled me to survive that journey without illness.

The train journey to Montreuil was much more comfortable. For one thing I had eaten a very good breakfast, and for another I found a compartment with all the windows intact and several passengers all puffing warmth from cigarettes and pipes. It was a joy to get back to the civilized G.H.Q. mess. Life at Meteor went on exactly as before; the war may have ended but the weather was always with us.

Early in January I said goodbye to everyone at Meteor, regretfully for, being one of the very lucky ones, because of the war I had profited both physically, owing to the open-air life, and intellectually. From an early age I have taken a delight in the processes of nature, those I could understand and those which, as yet, I could not understand. Without a doubt there is a strong streak of pantheism in my philosophical make-up. And so I fitted almost automatically into the organization of Meteor. By day and by night I had watched and recorded the ever-changing pageant of the sky, the magnitudes and kinds of the clouds from the filaments and frills of cirrus to the towering masses of cumulus reaching up into the sky and spreading out horizontally to form the thunderheads, precursors of the storm. Occasionally there would be a solar halo, and at night there was the occasional coloured lunar corona or the thin white circle of the lunar halo caused by reflection—not refraction—from minute ice crystals.

But, in spite of so much beauty, there was an unpleasant dichotomy which I could not always relegate to the back of my mind. The work of Meteor was not carried out to further the science of Meteorology but to make more accurate the processes of mass slaughter. When I was recording upper-air phenomena and computing the artillery wind corrections, I was, in a sense, serving with the artillery. After the war had changed its character from one of movement to one of the stalemate of the trenches, it changed from an infantryman's war to an artilleryman's war. As Hogg and Thurston point out in *British Artillery Weapons 1914/18*, there were operations in which more gunners were engaged than assaulting infantry. And yet, unless accurately directed, a bombardment could result in an unacceptable waste of ammunition. A vital factor affecting accuracy was the reliability of the wind corrections, and

it is no exaggeration to claim that the value of the artillery was, in large measure, dependent on the work of a handful of men, mostly of non-commissioned rank.

Thus I left Meteor with mixed feelings of gladness and of sorrow, and I marched down the hill to the railway station and to my strangest experience of all. I found that the most important function of a subaltern was to escort parties of men to those dreary places called rest camps. So, immediately my train arrived at Boulogne, before it had stopped even, every officer below the rank of captain dashed out and tried to find somewhere to hide; under the carriage, between the buffers, in the far corners of those enormous wagons labelled *hommes quarante chevaux six*. But it was not the slightest use, for by now the M.P.s knew all the tricks and I am quite sure they would have winkled out a man trying to hide in the smoke-box of the engine. Knowing the futility of these attempts to escape, I took my time and stepped out of the carriage straight into the welcoming arms of an M.P. I was conducted to a party of men at the foot of the hill leading to the rest camp. Fortunately for me they were already formed up in fours, so all I had to do was wait until the lot in front of me moved off, wave my arm, shout 'Come on', and follow up the hill.

Rest camp! That name must have been thought up by the G.H.Q. chief comedian. It was just about the bleakest place I had encountered, at the top of a bare hill and raked by wind from every quarter. What it must have been like during a blizzard, I couldn't imagine, and what the rest camp must have been like for the other ranks I couldn't imagine either. Everyone should have been delighted at the prospect of going home, this time for good, but there was precious little sign of happiness even among the P.B.I. who surely had the most cause for rejoicing.

After breakfast the fun started. A corporal conducted me to my bit of the army, two long rows of men, numbered them off, saluted and marched away. I looked at them and I hadn't the foggiest idea what to do. Everybody else's war was ended but mine was just starting. There was only one thing to do, and that was watch the party which would march off before mine and listen to the commands. The officer in charge had a loud voice and the command was: 'Move to the right in fours; form fours. Left turn. By your right, quick march'. I could easily memorize that for the time required but, unfortunately for me, I missed something very important. So in my best barrack-square voice I gave the command, 'Move to the right in fours'.

But they didn't move to the right, or to the left. They just looked at me and I looked at them. So I tried again but with the same negative result. Something was very wrong and I had no idea what it was. Being swallowed up by the providential opening up of the earth was not provided by an indifferent Nature, so there was only one thing to do. *Toujours l'audace* once again. I didn't know what to do but they did. So they should tell me and I would make it look as though it was their fault.

'What the bloody hell's the matter with you', I shouted, 'Don't you want to go home?'

That did the trick; a man in the rear rank called out, 'Please sir, you didn't say form fours'. So that was it, I ought to have given the order, 'Move to the right in fours; form fours'.

By this time I was thoroughly browned off by the ludicrous nature of the situation. If I tried again I would remember 'form fours' but possibly forget something else. So I shouted, 'O bloody hell, come on'.

I waved my arm, stalked off the battlefield and left my bit of the army to sort themselves out as best they could and follow me down to the docks. There were some brass-hats present but what they thought of the farce I had no idea, and didn't care either.

As though this fiasco wasn't enough there had to be another ludicrous incident on board ship. After seeing all the men on board, I decided that I never wished to see them again, so I found a corner on the boat where I fondly believed that I should remain undiscovered. I had not realized that if someone gives you a bit of the army the men will stick to you like a long-lost brother. Also, I did not know

that another of the subalterns' duties was to act as a nursemaid and sort out all the men's troubles.

It was a cold day with strong winds and heavy showers and it was obvious that we were in for a rough crossing. We had been at sea for half an hour or so when one of the men found me. His feet were bare and he carried trench boots, one in each hand. By this time nothing could surprise me, so I waited for his explanation. I expected that he had probably scrounged the boots and then, too late, found them too uncomfortable to wear. His trouble was that somebody had been seasick in one of them, and what could he do. I hadn't the least idea. Meteor had not taught me how to deal with a situation of this kind, and I forget what advice, if any, I proffered. I expect I had very little sympathy as I was still smarting from the comedy of 'form fours'.

So for me the most dreadful war in history ended on a note of farce.

(*Concluded*)

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The complete text of Dr Cotton's memoirs is available in the National Meteorological Library, Bracknell, and in the Imperial War Museum.

We print in this issue (see Plate XIII) a copy of a synoptic chart and weather report prepared by Dr Cotton while he was a member of Meteor; he presented this chart to the National Meteorological Library a few years ago.

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World Meteorological Organization Commission for Agricultural Meteorology (CAgM) Seventh Session, Sofia, September 1979

By W. R. Sparks

(Meteorological Office, Ministry of Agriculture, Fisheries and Food, Bristol)

Introduction

The seventh session of the WMO Commission for Agricultural Meteorology was held in the Conference Room of the Hotel Europa, Sofia, Bulgaria from 17 to 28 September 1979. Representatives of 53 countries, four international organizations and three non-governmental organizations took part in the plenary meetings; the United Kingdom delegates were Messrs C. V. Smith and W. R. Sparks. The session was opened with a speech by the Bulgarian Deputy Minister of Agriculture, Mr Ivan Tonev, and on the opening morning the Commission was also addressed by Academician C. Daskalov on behalf of the Bulgarian Academy of Sciences, Mr R. Schneider, Deputy Secretary General of WMO, Mr G. Popov, representing the Secretary of the United Nations Food and Agriculture Organization, Dr I. M. Nur, representative of the Organization of African Unity and finally by the President of the Commission, Dr W. Baier.

These opening speeches were not merely bland addresses of welcome to the delegates; they set the background against which the Commission must work. The President pointed out that during the 10-year period ending in 1975, world wheat production rose by 50 per cent, maize production by 38 per cent, sorghum by 35 per cent and rice production by 30 per cent; at the same time, world population increased by about 30 per cent. In order to increase food production in the 1980s at the same rate as the expected increase in population it will be necessary to continue to:

(1) Expand crop areas into present forests and pasture lands, into colder areas, drier areas, wetter areas and areas with problem soils.

(2) Increase yields on existing farmlands.

(3) Change farming systems so that more crops can be grown within a 12-month period on the same land. Such a policy of agricultural expansion is not without dangers. Already vast areas of once productive land have been lost and are still being lost by desertification and the Commission were reminded by Dr Nur that among the practices that can result in desertification are:

(a) Overgrazing.
(b) Cultivation of marginal land.
(c) Deforestation.

It is an uncomfortable fact that in many dry areas the intensity of agriculture that maximizes production in the average year can lead to desertification during a dry period. Similarly, in wet areas, agricultural practices that are profitable in most years may allow severe soil erosion during wet periods. There may be only a narrow path to tread between the production of adequate food for the population of the world and the destruction of the land from which that food must be produced.

With these thoughts in mind the Commission set about its three main tasks for the session:

(1) To review the progress since the previous session in 1974.

(2) To identify agricultural problems related to weather and climate.

(3) To propose a program of work and to appoint officers, working groups and rapporteurs to carry it out until the next session.

Review of progress

At its sixth session the Commission had established nine working groups and appointed 14 rapporteurs, but the ability of the seventh session to review their work was severely restricted by the absence of full reports. Many of the reports were available to the Secretariat but financial restrictions prevented their reproduction and distribution to delegates. CAgM-VI had set up two particularly ambitious working groups to carry out international experiments for the acquisition of weather data related to the cultivation of lucerne and wheat. The potential value of such international experiments is great because in a few years they allow a cultivar to be exposed to a range of weather conditions far greater than it would experience in most individual countries in a century. But the control of non-meteorological factors and the quality control of the data proved very difficult. Both working groups managed to complete experimental programs but since the data have not yet been analysed it was impossible to judge the success of the programs.

Lack of information made it impossible fully to assess the work of the Commission; nevertheless, it is pleasing to report that during the interval between the sixth and seventh sessions of the Commission, 11 WMO *Technical Notes*, three CAgM information reports and a book on 'Agricultural meteorology' were published. A number of other reports, including the revised 'Guide to agricultural meteorological practices', are in the course of publication.

Identification of major weather-related problems

The Commission had no difficulty in identifying problems that confront them; indeed the most important problems have been highlighted at major international meetings in recent years.

The World Food Conference explicitly called upon WMO to encourage the installation of observation and telecommunication networks in order that meteorological and climatological data could be placed at the disposal of the national authorities responsible for agriculture.

The United Nations conference on desertification called on WMO to support its plan of action. The World Climate Conference unanimously designated agriculture as one of the high-priority areas for work within the Climate Applications Program and the Climate Impact Study Program.

Proposed program of work

Between sessions the Commission carries on its work through its President and his Advisory Working Group, and also through specialized working groups and rapporteurs. The Commission responded to the request by the World Food Conference by setting up working groups on 'Data requirements for agriculture' and 'The agricultural services in developing countries', and appointing rapporteurs on 'Agroclimatic maps', 'Drought probability maps' and 'Wild land fires'. The Commission's main support for the WMO plan of action against desertification will be through the working group on 'Agrometeorological aspects of land management in arid and semi-arid areas' whilst the main contribution to the World Climate Program will be through working groups on 'Impact of climate variability on agriculture and agricultural activities on climate', 'The role of forests in the global balances of carbon dioxide, water and energy' and 'Meteorological aspects of agriculture in humid and sub-humid tropical areas'. In support of this program the Commission also appointed rapporteurs on 'Soil water studies' and 'Air pollution and plant injury'.

Much of the work described above is dependent on knowledge of the relationships between weather and crop and animal production. The Commission therefore planned to supplement its work on the major problems by continuing the analysis of the weather data for the lucerne- and wheat-cultivation and establishing working groups on 'Weather and animal health' and 'The effects of meteorological factors on maize development and yield'. It also appointed a rapporteur on 'The application of models for forecasting development and ripening of crops'.

In order to rationalize the WMO calendar of meetings CAgM-VIII will be held late in 1982 so that the Commision has only three years under its new President, Dr N. Gerbier of France, and its new Vice-President, Dr J. J. Burgos of Argentina, to complete the program of work it has set for itself.

Impressions of the session

In addition to the factual report of the session the impressions of a delegate attending a meeting of the Commission for the first time may be of interest.

It was clear that the great majority of delegates were convinced that agricultural meteorology has a vital role to play if the world's food supply is to be expanded to keep pace with the increasing population without at the same time placing the productive capacity of the land at risk. The problems were discussed on a global or regional basis and national and political prejudices showed only rarely. The problems of developing countries received a great deal of attention and delegates from many of those countries contributed fully to the discussions. Among the African delegates, those from the ex-British colonies were particularly active and their representation on the newly established working groups of

the Commission is far greater than that of the United Kingdom, which is represented on only two of the working groups. This level of contribution from the United Kingdom was not due to our reluctance to volunteer names for working groups but to the large number of candidates put forward by other delegations, and the nomination and selection procedures adopted by the Commission. It should also be said that although our present involvement with the work of the Commission is slight compared with our own past standards, it is comparable with that of all other western European countries with the exception of France, which now has the Presidency.

A meeting of a WMO Commission relies very heavily on the services of the WMO Secretariat to keep it on schedule and, although there were times when I felt that I was being beaten into submission by the sheer weight of paper heaped upon me, I finished the fortnight with a considerable respect for the efficiency and patience of the translators and the WMO staff whose work was carried out under less than ideal conditions.

I found the experience of attending a session of CAgM exhausting but interesting. Particularly rewarding were informal discussions with agricultural meteorologists from other countries about the services they provide and the opportunities and frustrations of their work. It appears that the resources devoted by the United Kingdom to agricultural meteorology are small compared with those of many other countries and it is clear that we must use our resources with great efficiency if we are to maintain our place among the leaders in the provision of meteorological services to agriculture.

Review

Pathways of pollutants in the atmosphere (*A Royal Society discussion organized by T. M. Sugden, F.R.S. for the Royal Society's Study Group on Pollution in the Atmosphere, held on 3 and 4 November 1977*). The Royal Society of London. 290 mm × 210 mm, pp. vi + 169, *illus*. The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, 1979. Price £12.90 (United Kingdom addresses, including packing and postage) and £13.30 (overseas addresses, including packing and postage).

This volume contains papers presented at a Royal Society Discussion Meeting organized as part of the program of work of its Study Group on Pollution in the Atmosphere and first published in *Philosophical Transactions of the Royal Society of London*, Series A, Volume 290 (No. 1376), pages 467–637. It comprises twelve major invited contributions by leading experts in different branches of the subject followed in most cases by short reports of the ensuing discussion and, as would be expected, provides an authoritative and up-to-date review of the present state of knowledge in this area and the philosophies of future monitoring and control of atmospheric pollution.

The pathways through the atmosphere of materials from their emission regions or 'sources' to their removal regions or 'sinks' involve transport and dispersal by the atmospheric motions during which changes due to chemical and physical processes generally occur. The pollution problems may be essentially global, regional or local and consequently their study may require meteorological information extending from the boundary layer to the stratosphere or above as well as appropriate data on the atmospheric physics and chemistry. In addition to establishing the exposure of all the 'targets' or receptors of the pollutants (e.g. humans, animals, plants, ecological systems, human artefacts and indirectly, climate) it is necessary to produce reliable dose-effect data which involve many different scientific disciplines. Given the overall scientific basis linking the sources to the final effects it is then necessary to seek, taking into account the existence of natural sources, the best policies for the control and monitoring of the pollution in the future.

The background to the current problems is reviewed by T. M. Sugden in the Preface and in the first paper 'The classification of pollutants and their pathways in the atmosphere'. In this he identifies the trends which have directed increased attention to atmospheric pollution in recent years, namely the impact of new and increased technology and the growing social awareness of its possible hazards. This has resulted in this country *inter alia* in an acceleration of governmental studies on pollution controls, a recent Royal Commission Report, and detailed studies by the Royal Society Study Group on a wide variety of pollution topics. The last include (i) possible global effects arising from stratospheric aircraft flights, increased use of nitrogenous fertilizers and fluorocarbon releases on stratospheric ozone and also possible climatic changes following increases of carbon dioxide in the atmosphere (ii) regional effects produced by the transport of sulphur compounds in north-west Europe (iii) local effects due to airborne heavy metals and (iv) the philosophy and practice of air pollution monitoring. Transient pollution due to accidental releases of toxic substances has also been considered.

Papers relevant to the problem of possible decreases in stratospheric ozone and the consequent increase of potentially dangerous ultra-violet radiation at the earth's surface include a review of the complex photochemistry involved together with recent results from laboratory studies by B. A. Thrush, an investigation of the current atmospheric modelling techniques used in the assessment of possible ozone reduction by A. F. Tuck and a comprehensive review of atmospheric nitrous oxide (considered to be the main source of nitrogen oxides in the stratosphere) by J. Hahn. All of these papers present recent work and are of great interest to specialists and other workers in the area. It would have been more helpful to the general reader of this book (as contrasted with the usual reader of the Royal Society's *Philosophical Transactions*) if more background and possibly some historical information on this overall problem had been included somewhere in this group. In contrast the following paper, a review by J. T. Houghton of possible climatic changes arising as a result of the 'greenhouse effect' due to an increase of carbon dioxide from the burning of fossil fuels or the release of chlorofluorocarbons in the atmosphere, is self-contained and a useful introduction for any scientists interested in atmospheric processes.

The regional problem as exemplified by the transport, dispersion and deposition of sulphur pollutants over western Europe is well covered in a very informative article (which also reports studies initiated by the Organization for Economic Co-operation and Development) by F. B. Smith and R. D. Hunt. This is followed by a detailed discussion by R. A. Cox of the photochemical oxidation of atmospheric sulphur dioxide.

In local pollution problems the contribution of meteorologists is mainly through assessment of short-range dispersion by winds in the boundary layer. This approach is used together with measurements of particle sizes and concentrations in an important study by A. C. Chamberlain and his colleagues of the dispersion of lead from motor exhausts. Another comprehensive and specialized paper on atmospheric chemistry relating to conditions near the surface is given by J. N. Pitts Jr whose subject concerns types of 'non-criteria pollutants' (the nomenclature in the U.S.A. for pollutants other than the well-known 'criteria pollutants' sulphur dioxide, carbon monoxide, nitrogen dioxide, photochemical oxidant (including ozone) and total suspended particulates) and is entitled 'Photochemical and biological implications of the atmospheric reactions of amines and benzo(a)pyrene'.

Questions of the factors determining the amount of damage that is likely to be caused to a receptor by a given dose of pollutant (the product of concentration and time of exposure) are discussed by M. W. Holdgate. These include variations in target sensitivity and the effects of single and multiple impacts and the author concludes that there is a need for an integrated approach including epidemiological studies, controlled experiments relating dose to effect and lastly models to provide a framework for interpreting the system as a whole. The subject of monitoring for explanation, observation and

control is then discussed in some detail by J. S. Reay with the important reminder that monitoring is not to be confused with mindless measurement. Finally the philosophy of control of air pollution in the United Kingdom which is based on the 'best practicable means' concept, in which it is recognized that a degree of air pollution is inevitable in present-day industrial society, and strives to optimize this pollution so that the total interest of society is best served, is expounded by F. E. Ireland and D. J. Bryce.

In summary, this collection of papers is clearly of great importance and provides a very useful reference to the present overall state of the subject both as regards scientific progress and its application to the practical problems involved. This presumably is the reason why the decision was taken to reproduce these *Philosophical Transactions* as a book easily accessible in libraries to a more general readership. At the same time it should be noted that the coverage is not uniform, some of the articles being quite easily read and understood by scientists and others on the fringe of the subject while some of the papers, although of great importance in their own right, can only be fully appreciated by specialists in the relevant field. It would have been helpful if the Royal Society document 'Pollution in the Atmosphere; Final Report of a Royal Society Study Group' published in June 1978 could also have been incorporated in this book to provide additional background and the interested reader is also advised to obtain this document.

R. J. Murgatroyd

Obituary

We regret to record the death on 26 October 1979 of Mr J. A. Lynch, Higher Scientific Officer. Mr Lynch first joined the Office as an Assistant in 1941. After service with the RAF Met. Branch, he was reinstated as a civilian in 1947, and from 1950 to 1959 he occupied a Senior Assistant post at ATCC Uxbridge. In March 1959 he was posted to the meteorological equipment (stores) section of M.O.4 in Harrow, and in this post became known to many members of the Office; his hard work made a valuable contribution to the smooth functioning of Headquarters branches and outstations alike. He was promoted to Higher Scientific Officer in 1978.

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NOTICES

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